Claims

[c1] 1. A method of forming bumps on a silicon wafer having an active surface with a passivation layer and a plurality of bonding pads thereon such that the passivation layer exposes the bonding pads, the method comprising the steps of:

forming an adhesion layer over the active surface of the wafer, covering both the bonding pads and the passivation layer;

forming a barrier layer over the adhesion layer;

forming a wettable layer over the barrier layer;

conducting a first photolithographic process to from a plurality of photoresist blocks on the wettable layer;

conducting a first etching operation to remove the wettable layer and the barrier layer outside the photoresist blocks so that only the residual wettable layer and barrier layer underneath the photoresist blocks remain;

removing the photoresist blocks;

conducting a second photolithographic process to form a photoresist layer over the adhesion layer, wherein the photoresist layer has a plurality of openings that expose the wettable layer and the adhesion layer around the barrier layer;

conducting a metal-filling operation to form solder blocks inside the openings of the photoresist layer, wherein the solder blocks cover the wettable layer and the adhesion layer around the barrier layer;

removing the photoresist layer;

conducting a first reflux operation to transform the solder blocks into a blob of material having a hemispherical profile such that the solder blocks also retract onto the upper surface of the wettable layer without extending into the adhesion layer;

conducting a second etching operation to remove the exposed adhesion layer so that only residual adhesion layer underneath the barrier layer is retained and the passivation layer on the wafer is exposed; and

conducting a second reflux operation.

[c2] 2. The method of claim 1, wherein material constituting the adhesion layer is selected from a group consisting of titanium, titanium-tungsten alloy,

aluminum and chromium.

[c3] 3. The method of claim 2, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen peroxide (H_2O_2), ethylene diaminete traacetic (EDTA) and potassium sulfate (K_2SO_4) when the adhesion layer is a titanium-tungsten alloy layer.

[c4] 4. The method of claim 2, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen chloride (HCl) when the adhesion layer is a chromium layer.

[c5] 5. The method of claim 2, wherein etchant for etching the adhesion layer in the second etching operation contains ammonium hydroxide (NH_4OH) and hydrogen peroxide (H_2O_2) when the adhesion layer is a titanium layer.

[c6] 6. The method of claim 2, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen fluoride (HF) when the adhesion layer is a titanium layer.

[c7] 7. The method of claim 2, wherein etchant for etching the adhesion layer in the second etching operation contains phosphoric acid and acetic acid when the adhesion layer is an aluminum layer.

[c8] 8. The method of claim 1, wherein material constituting the barrier layer includes nickel-vanadium alloy.

[c9] 9. The method of claim 8, wherein the etchant for etching the barrier layer in the first etching operation contains sulfuric acid.

[c10] 10. The method of claim 9, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at room temperature using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c11] 11. The method of claim 9, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at 80 ° C using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c12] 12. The method of claim 9, wherein the barrier layer having a thickness between

2000 Å to 4000 Å is etched in the first etching operation by conducting an electrochemical etching operation at room temperature for 20 to 110 seconds using a current density between 0.001 ~ 0.02A/cm^2 and sulfuric acid at 10% concentration.

[c13] 13. The method of claim 8, wherein the barrier layer is etched using diluted phosphoric acid in the first etching operation.

[c14] 14. The method of claim 1, wherein material constituting the wettable layer is selected from a group consisting of copper, palladium and gold.

[c15] 15. The method of claim 14, wherein the wettable layer is etched in the first etching operation using an etchant containing ammonium hydroxide and hydrogen peroxide if the wettable layer is a copper layer.

[c16] 16. The method of claim 14, wherein the wettable layer is etched in the first etching operation using an etchant containing potassium sulfate (K_2SO_4) and glycerol if the wettable layer is a copper layer.

[c17] 17. The method of claim 1, wherein material constituting the solder blocks does not wet the adhesive layer.

[c18] 18. A method of forming bumps on a silicon wafer having an active surface with a passivation layer and a plurality of bonding pads thereon such that the passivation layer exposes the bonding pads, the method comprising the steps of:

forming an adhesion layer over the active surface of the wafer, covering both the bonding pads and the passivation layer;

forming a barrier layer over the adhesion layer;

forming a wettable layer over the barrier layer;

conducting a first photolithographic process to from a plurality of photoresist blocks on the wettable layer;

conducting a first etching operation to remove the wettable layer and the barrier layer outside the photoresist blocks so that only the residual wettable layer and barrier layer underneath the photoresist blocks remain;

removing the photoresist blocks;

conducting a second photolithographic process to form a photoresist layer over the adhesion layer, wherein the photoresist layer has a plurality of openings that expose the wettable layer and the adhesion layer around the barrier layer;

conducting a metal-filling operation to form solder blocks inside the openings of the photoresist layer, wherein the solder blocks cover the wettable layer and the adhesion layer around the barrier layer;

conducting a first reflux operation to transform the solder blocks into a blob of material having a hemispherical profile such that the solder blocks also retract onto the upper surface of the wettable layer without extending into the adhesion layer;

removing the photoresist layer;

conducting a second etching operation to remove the exposed adhesion layer so that only residual adhesion layer underneath the barrier layer is retained and the passivation layer on the wafer is exposed; and

conducting a second reflux operation.

[c19] 19. The method of claim 1, wherein material constituting the adhesion layer is selected from a group consisting of titanium, titanium-tungsten alloy, aluminum and chromium.

[c20] 20. The method of claim 19, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen peroxide (H_2O_2), ethylene diamine tetraacetic (EDTA) and potassium sulfate (K_2SO_4) when the adhesion layer is a titanium-tungsten alloy layer.

[c21] 21. The method of claim 19, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen chloride (HCl) when the adhesion layer is a chromium layer.

[c22] 22. The method of claim 19, wherein etchant for etching the adhesion layer in the second etching operation contains ammonium hydroxide (NH_4OH) and hydrogen peroxide (H_2O_2) when the adhesion layer is a titanium layer.

[c23] 23. The method of claim 19, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen fluoride (HF) when the

adhesion layer is a titanium layer.

[c24] 24. The method of claim 19, wherein etchant for etching the adhesion layer in the second etching operation contains phosphoric acid and acetic acid when the adhesion layer is an aluminum layer.

[c25] 25. The method of claim 18, wherein material constituting the barrier layer includes nickel-vanadium alloy.

[c26] 26. The method of claim 25, wherein the etchant for etching the barrier layer in the first etching operation contains sulfuric acid.

[c27] 27. The method of claim 26, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at room temperature using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c28] 28. The method of claim 26, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at 80 ° C using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c29] 29. The method of claim 26, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched in the first etching operation by conducting an electrochemical etching operation at room temperature for 20 to 110 seconds using a current density between 0.001 ~ 0.02A/cm ^{2} and sulfuric acid at 10% concentration.

[c30] 30. The method of claim 25, wherein the barrier layer is etched using diluted phosphoric acid in the first etching operation.

[c31] 31. The method of claim 18, wherein material constituting the wettable layer is selected from a group consisting of copper, palladium and gold.

[c32] 32. The method of claim 31, wherein the wettable layer is etched in the first etching operation using an etchant containing ammonium hydroxide and hydrogen peroxide if the wettable layer is a copper layer.

[c33] 33. The method of claim 31, wherein the wettable layer is etched in the first etching operation using an etchant containing potassium sulfate (K_2SO_4) and

glycerol if the wettable layer is a copper layer.

[c34] 34. The method of claim 18, wherein material constituting the solder blocks does not wet the adhesive layer.

[c35] 35. A method of forming bumps over a silicon wafer having an active surface thereon, the method comprising the steps of:
forming a first under-ball metallic layer over the active surface of the wafer;
forming a second under-ball metallic layer over the first under-ball metallic layer;
conducting a first photolithographic process to form a plurality of photoresist blocks over the second under-ball metallic layer;
conducting a first etching operation to remove the second under-ball metallic layer outside the photoresist blocks so that only the second under-ball metallic layer underneath the photoresist blocks remains;
removing the photoresist blocks;
conducting a second photolithographic process to form a photoresist layer over the second under-ball layer, wherein the photoresist layer has a plurality of openings that expose the second under-ball metallic layer;
conducting a metal-filling operation by depositing metallic material into the openings in the photoresist layer to form solder blocks that cover the second under-ball metallic layer;
removing the photoresist layer;
conducting a reflux operation to transform the solder blocks into a blob of material having a hemispherical profile; and
conducting a second etching operation to remove the exposed first under-ball metallic layer so that only the first under-ball metallic layer underneath the second under-ball metallic layer remains.

[c36] 36. The method of claim 35, wherein after the second etching operation further includes a second reflux operation.

[c37] 37. The method of claim 35, wherein the step of forming the second under-ball metallic layer over the first under-ball metallic layer includes the sub-steps of:
forming a barrier layer over the first under-ball metallic layer; and

forming a wettable layer over the barrier layer.

[c38] 38. The method of claim 37, wherein material constituting the barrier layer includes nickel-vanadium alloy.

[c39] 39. The method of claim 38, wherein the first etching operation is carried out using an etchant containing sulfuric acid.

[c40] 40. The method of claim 39, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at room temperature using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c41] 41. The method of claim 39, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at 80 ° C using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c42] 42. The method of claim 39, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched in the first etching operation by conducting an electrochemical etching operation at room temperature for 20 to 110 seconds using a current density between 0.001 ~ 0.02A/cm ^{2} and sulfuric acid at 10% concentration.

[c43] 43. The method of claim 38, wherein the barrier layer is etched using diluted phosphoric acid in the first etching operation.

[c44] 44. The method of claim 37, wherein material constituting the wettable layer is selected from a group consisting of copper, palladium and gold.

[c45] 45. The method of claim 44, wherein the wettable layer is etched in the first etching operation using an etchant containing ammonium hydroxide and hydrogen peroxide if the wettable layer is a copper layer.

[c46] 46. The method of claim 44, wherein the wettable layer is etched in the first etching operation using an etchant containing potassium sulfate (K_2SO_4) and glycerol if the wettable layer is a copper layer.

[c47] 47. The method of claim 35, wherein the first under-ball metallic layer includes an adhesion layer fabricated using a material selected from a group consisting

of titanium, titanium-tungsten alloy, aluminum and chromium.

[c48] 48. The method of claim 47, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen peroxide (H_2O_2), ethylene diamine tetraacetic (EDTA) and potassium sulfate (K_2SO_4) when the adhesion layer is a titanium-tungsten alloy layer.

[c49] 49. The method of claim 47, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen chloride (HCl) when the adhesion layer is a chromium layer.

[c50] 50. The method of claim 47, wherein etchant for etching the adhesion layer in the second etching operation contains ammonium hydroxide (NH_4OH) and hydrogen peroxide (H_2O_2) when the adhesion layer is a titanium layer.

[c51] 51. The method of claim 47, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen fluoride (HF) when the adhesion layer is a titanium layer.

[c52] 52. The method of claim 47, wherein etchant for etching the adhesion layer in the second etching operation contains phosphoric acid and acetic acid when the adhesion layer is an aluminum layer.

[c53] 53. The method of claim 35, wherein material constituting the solder blocks does not wet the first under-ball metallic layer.

[c54] 54. A method of forming bumps over a silicon wafer having an active surface thereon, the method comprising the steps of:

forming a first under-ball metallic layer over the active surface of the wafer;

forming a second under-ball metallic layer over the first under-ball metallic layer;

conducting a first photolithographic process to form a plurality of photoresist blocks over the second under-ball metallic layer;

conducting a first etching operation to remove the second under-ball metallic layer outside the photoresist blocks so that only the second under-ball metallic layer underneath the photoresist blocks remains;

removing the photoresist blocks;

conducting a second photolithographic process to form a photoresist layer over the second under-ball layer, wherein the photoresist layer has a plurality of openings that expose the second under-ball metallic layer;

conducting a metal-filling operation by depositing metallic material into the openings in the photoresist layer to form solder blocks that cover the second under-ball metallic layer;

conducting a reflux operation to transform the solder blocks into a blob of material having a hemispherical profile;

removing the photoresist layer; and

conducting a second etching operation to remove the exposed first under-ball metallic layer so that only the first under-ball metallic layer underneath the second under-ball metallic layer remains.

[c55] 55. The method of claim 54, wherein after the second etching operation further includes a second reflux operation.

[c56] 56. The method of claim 54, wherein the step of forming the second under-ball metallic layer over the first under-ball metallic layer includes the sub-steps of:

forming a barrier layer over the first under-ball metallic layer; and

forming a wettable layer over the barrier layer.

[c57] 57. The method of claim 56, wherein material constituting the barrier layer includes nickel-vanadium alloy.

[c58] 58. The method of claim 57, wherein the first etching operation is carried out using an etchant containing sulfuric acid.

[c59] 59. The method of claim 58, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at room temperature using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c60] 60. The method of claim 58, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at 80 ° C using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c61] 61. The method of claim 58, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched in the first etching operation by conducting an electrochemical etching operation at room temperature for 20 to 110 seconds using a current density between 0.001 ~ 0.02A/cm ^{2} and sulfuric acid at 10% concentration.

[c62] 62. The method of claim 57, wherein the barrier layer is etched using diluted phosphoric acid in the first etching operation.

[c63] 63. The method of claim 56, wherein material constituting the wettable layer is selected from a group consisting of copper, palladium and gold.

[c64] 64. The method of claim 63, wherein the wettable layer is etched in the first etching operation using an etchant containing ammonium hydroxide and hydrogen peroxide if the wettable layer is a copper layer.

[c65] 65. The method of claim 63, wherein the wettable layer is etched in the first etching operation using an etchant containing potassium sulfate (K_2SO_4) and glycerol if the wettable layer is a copper layer.

[c66] 66. The method of claim 54, wherein the first under-ball metallic layer includes an adhesion layer fabricated using a material selected from a group consisting of titanium, titanium-tungsten alloy, aluminum and chromium.

[c67] 67. The method of claim 66, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen peroxide (H_2O_2), ethylene diamine tetraacetic (EDTA) and potassium sulfate (K_2SO_4) when the adhesion layer is a titanium-tungsten alloy layer.

[c68] 68. The method of claim 66, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen chloride (HCl) when the adhesion layer is a chromium layer.

[c69] 69. The method of claim 66, wherein etchant for etching the adhesion layer in the second etching operation contains ammonium hydroxide (NH_4OH) and hydrogen peroxide (H_2O_2) when the adhesion layer is a titanium layer.

[c70] 70. The method of claim 66, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen fluoride (HF) when the adhesion layer is a titanium layer.

[c71] 71. The method of claim 66, wherein etchant for etching the adhesion layer in the second etching operation contains phosphoric acid and acetic acid when the adhesion layer is an aluminum layer.

[c72] 72. The method of claim 54, wherein material constituting the solder blocks does not wet the first under-ball metallic layer.

[c73] 73. A method of forming bumps over a silicon wafer having an active surface thereon, the method comprising the steps of:
forming a first under-ball metallic layer over the active surface of the wafer;
forming a second under-ball metallic layer over the first under-ball metallic layer;
conducting a first photolithographic process to form a plurality of photoresist blocks over the second under-ball metallic layer;
conducting a first etching operation to remove the second under-ball metallic layer outside the photoresist blocks so that only the second under-ball metallic layer underneath the photoresist blocks remains;
removing the photoresist blocks;
conducting a second photolithographic process to form a photoresist layer over the second under-ball layer, wherein the photoresist layer has a plurality of openings that exposes the second under-ball metallic layer;
conducting a metal-filling operation by depositing metallic material into the openings in the photoresist layer to form solder blocks that cover the second under-ball metallic layer;
removing the photoresist layer;
conducting a reflux operation to transform the solder blocks into a blob of material having a hemispherical profile; and
conducting a second etching operation to remove the exposed first under-ball metallic layer so that only the first under-ball metallic layer underneath the second under-ball metallic layer remains.

[c74] 74. The method of claim 73, wherein after the second etching operation further includes a second reflux operation.

[c75] 75. The method of claim 73, wherein the first reflux operation is carried out after the photoresist layer is removed.

[c76] 76. The method of claim 73, wherein the photoresist layer is removed after the first reflux operation is carried out.

[c77] 77. The method of claim 73, wherein the step of forming the second under-ball metallic layer over the first under-ball metallic layer includes the sub-steps of:
forming a barrier layer over the first under-ball metallic layer; and
forming a wettable layer over the barrier layer.

[c78] 78. The method of claim 77, wherein material constituting the barrier layer includes nickel-vanadium alloy.

[c79] 79. The method of claim 78, wherein the first etching operation is carried out using an etchant containing sulfuric acid.

[c80] 80. The method of claim 79, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at room temperature using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c81] 81. The method of claim 79, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at 80 ° C using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c82] 82. The method of claim 79, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched in the first etching operation by conducting an electrochemical etching operation at room temperature for 20 to 110 seconds using a current density between 0.001 ~ 0.02A/cm ^{2} and sulfuric acid at 10% concentration.

[c83] 83. The method of claim 78, wherein the barrier layer is etched using diluted phosphoric acid in the first etching operation.

[c84] 84. The method of claim 77, wherein material constituting the wettable layer is

selected from a group consisting of copper, palladium and gold.

[c85] 85. The method of claim 84, wherein the wettable layer is etched in the first etching operation using an etchant containing ammonium hydroxide and hydrogen peroxide if the wettable layer is a copper layer.

[c86] 86. The method of claim 84, wherein the wettable layer is etched in the first etching operation using an etchant containing potassium sulfate (K_2SO_4) and glycerol if the wettable layer is a copper layer.

[c87] 87. The method of claim 73, wherein the first under-ball metallic layer includes an adhesion layer fabricated using a material selected from a group consisting of titanium, titanium-tungsten alloy, aluminum and chromium.

[c88] 88. The method of claim 87, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen peroxide (H_2O_2), ethylene diamine tetraacetic (EDTA) and potassium sulfate (K_2SO_4) when the adhesion layer is a titanium-tungsten alloy layer.

[c89] 89. The method of claim 87, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen chloride (HCl) when the adhesion layer is a chromium layer.

[c90] 90. The method of claim 87, wherein etchant for etching the adhesion layer in the second etching operation contains ammonium hydroxide (NH_4OH) and hydrogen peroxide (H_2O_2) when the adhesion layer is a titanium layer.

[c91] 91. The method of claim 87, wherein etchant for etching the adhesion layer in the second etching operation contains hydrogen fluoride (HF) when the adhesion layer is a titanium layer.

[c92] 92. The method of claim 87, wherein etchant for etching the adhesion layer in the second etching operation contains phosphoric acid and acetic acid when the adhesion layer is an aluminum layer.

[c93] 93. The method of claim 73, wherein material constituting the solder blocks does not wet the first under-ball metallic layer.

[c94] 94. A method of forming bumps over the active surface of a silicon wafer, the method comprising the steps of:
forming a first under-ball metallic layer over the active surface of the wafer;
forming a second under-ball metallic layer over the first under-ball metallic layer;
removing a portion of the second under-ball metallic layer to expose the first under-ball metallic layer;
implanting at least one solder block over the second under-ball metallic layer;
conducting a reflux operation; and
removing the exposed first under-ball metallic layer so that the first under-ball metallic layer underneath the second under-ball metallic layer remains.

[c95] 95. The method of claim 94, wherein after removing the exposed first under-ball metallic layer, further includes conducting a second reflux operation.

[c96] 96. The method of claim 94, wherein the step of forming the second under-ball metallic layer over the first under-ball metallic layer includes the sub-steps of:
forming a barrier layer over the first under-ball metallic layer; and
forming a wettable layer over the barrier layer.

[c97] 97. The method of claim 96, wherein material constituting the barrier layer includes nickel-vanadium alloy.

[c98] 98. The method of claim 97, wherein the first etching operation is carried out using an etchant containing sulfuric acid.

[c99] 99. The method of claim 98, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at room temperature using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c100] 100. The method of claim 98, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched for over 2 hours at 80 ° C using a sulfuric acid etchant having a concentration between 1% ~ 98%.

[c101] 101. The method of claim 98, wherein the barrier layer having a thickness between 2000 Å to 4000 Å is etched in the first etching operation by

conducting an electrochemical etching operation at room temperature for 20 to 110 seconds using a current density between 0.001 ~ 0.02A/cm^2 and sulfuric acid at 10% concentration.

[c102] 102. The method of claim 97, wherein the barrier layer is etched using diluted phosphoric acid in the first etching operation.

[c103] 103. The method of claim 96, wherein material constituting the wettable layer is selected from a group consisting of copper, palladium and gold.

[c104] 104. The method of claim 103, wherein the wettable layer is etched in the first etching operation using an etchant containing ammonium hydroxide and hydrogen peroxide if the wettable layer is a copper layer.

[c105] 105. The method of claim 103, wherein the wettable layer is etched in the first etching operation using an etchant containing potassium sulfate (K_2SO_4) and glycerol if the wettable layer is a copper layer.

[c106] 106. The method of claim 94, wherein the first under-ball metallic layer includes an adhesion layer fabricated using a material selected from a group consisting of titanium, titanium-tungsten alloy, aluminum and chromium.

[c107] 107. The method of claim 106, wherein the exposed first under-ball metallic layer is removed by etching and etchant for etching the adhesion layer contains hydrogen peroxide (H_2O_2), ethylene diamine tetraacetic (EDTA) and potassium sulfate (K_2SO_4) when the adhesion layer is a titanium-tungsten alloy layer.

[c108] 108. The method of claim 106, wherein the exposed first under-ball metallic layer is removed by etching and etchant for etching the adhesion layer contains hydrogen chloride (HCl) when the adhesion layer is a chromium layer.

[c109] 109. The method of claim 106, wherein the exposed first under-ball metallic layer is removed by etching and etchant for etching the adhesion layer contains ammonium hydroxide (NH_4OH) and hydrogen peroxide (H_2O_2) when the adhesion layer is a titanium layer.

[c110] 110. The method of claim 106, wherein the exposed first under-ball metallic layer is removed by etching and etchant for etching the adhesion layer contains hydrogen fluoride (HF) when the adhesion layer is a titanium layer.

[c111] 111. The method of claim 106, wherein the exposed first under-ball metallic layer is removed by etching and etchant for etching the adhesion layer contains phosphoric acid and acetic acid when the adhesion layer is an aluminum layer.

[c112] 112. The method of claim 94, wherein material constituting the solder blocks does not wet the first under-ball metallic layer.